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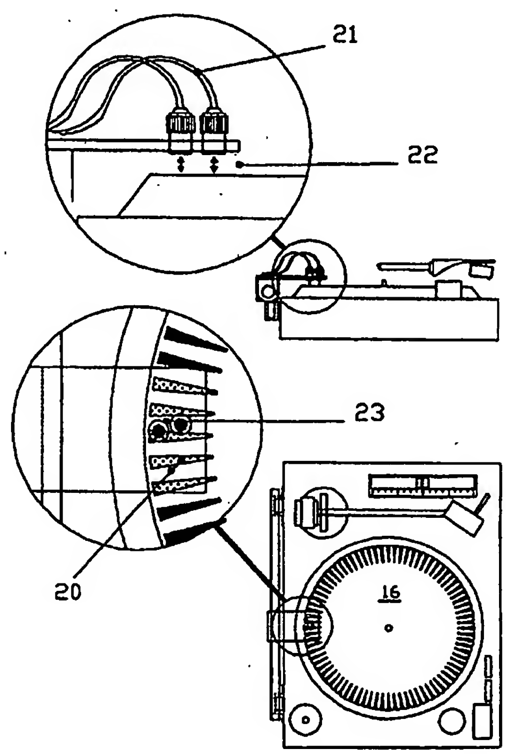
(54) Title: DIGITAL PROCESSING DEVICE FOR AUDIO SIGNAL

(57) Abstract

A system for the digital processing of audio signals, particularly for disc jockeys and scratch musicians. The speed and direction of reproduction of an audio signal coming from an external source, e.g., from a CD player, can be controlled by acting manually on a rotating element (16). The speed of rotation of this element is normally constant but can be modified by the disc jockey. The sampled audio signal is stored at a constant frequency in a sampling buffer and read at a variable frequency as a function of the speed and direction of the rotating element. In one embodiment, the element (16) is a record player turntable. The disc jockey can act upon the speed of rotation. An optical sensor (21) determines the speed and direction of rotation of the turntable. These data are used to determine the speed and direction of reproduction of an external audio signal, e.g., coming from a CD player.



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Digital Processing Device for Audio Signal

The present invention relates to a digital processing device for an audio signal.

At the beginning of the 1980's, disc jockeys developed a technique for producing novel sounds which had, in their own way, a typical, unmistakable character, and which could not be produced in any other way : the so-called SCRATCHING. This is generally understood to mean the rhythmical interplay of forward and backward movements of a record being played, as well as the simultaneous modulation of the volume by means of a slide control. Scratching is mixed in time with a piece being played for the purpose of mixing the scratched musical phrase at the original speed in the beat intervals of the piece being played at the right moment. At the end of the phrase, the record is inaudibly rotated back to the starting position of the phrase, and the procedure is repeated a number of times, the appeal being to modify the repetitions and to produce musical suspense by continuously stepping up the tricks.

In recent years, scratching has become established as a generally acknowledged musical instrument and has been utilized in numerous music productions. More and more music groups are also using scratch musicians live.

However, the conventional method of using an analog record as the sound carrier has serious disadvantages, the elimination of which is the object of the present invention. For one thing, there is enormous wear and tear on material. Records wear out very quickly and must be replaced after a few hours of use ; and as digital compact discs come to take over more and more from analog records, this leads to procurement problems. The consumption of needles is also enormous. The rapid changes of direction and speed produce centrifugal forces which lead to great distortions of the music signal and, when play is too fast, cause the needle to jump out of the current groove and put an abrupt end to the performance.

Moreover, this conventional method can be applied only with LP's. Increasingly, however, other sources of music are used, particularly digital sources such as CD's or tapes, the use of LP's tending to decline or even disappear.

Furthermore, conventional methods do not allow several musical phrases to be combined or played simultaneously ; the record must be repositioned for that.

According to the known prior art, so-called scratch aids exist for digital recording-and-playback apparatus (music samplers) in the form of scratch discs, slide potentiometers, knobs, etc.

The decisive drawback of this kind of transcription is always the lack of a mechanically generated speed reference allowing an instantaneous changeover between manipulated and original reproduction. Since, besides scratching, there is also a demand for the possibility of immediate correction in case of the premature or delayed start of a phrase which is supposed to run synchronously with a piece already playing, all respective apparatus offered thus far are hardly suitable. Changing at the touch of a button between manipulated speed and an electronically generated reference takes too long and is, moreover, so hard to control that attempts at error correction usually end up to be the opposite. A practiced disc jockey synchronizes on record players by hand, inaudibly for the listener, in the first tenths of a second during the start of the phrase. In time, the disc jockey becomes quite familiar with this procedure, and it takes place fully automatically, so that he can concentrate entirely on the remix. All attempts at being able to reproduce electronically this complex function which the human brain takes care of autonomously are doomed to failure from the outset.

The object of the invention is to propose a device which avoids the drawbacks of the prior art.

This object is achieved especially thanks to the novel elements of claim 1. In particular, this object is achieved thanks to a reference generated

mechanically and making it possible to pass instantly from normal reproduction to manipulated reproduction.

Furthermore, this object is achieved thanks to an element which moves during the reproduction of said audio signal, the speed and the direction of reproduction of said audio signal being manually controllable by control of the speed and direction of said element.

Since the users of such apparatus usually already have record players on hand, and the necessary manual skill is already well practiced, it makes good sense to use a record player as moving element. However, for novices or for portable apparatus, the invention can be realized using any other kind of moving element, for instance a running belt or a rotating knob or control button on the front panel of an audiomixer.

The invention will be better understood with the aid of the description and the accompanying drawings, in which :

Figure 1A is a front elevation of a first embodiment of the invention wherein the movable element, the speed and direction of which can be controlled, is made up of a record-player turntable ;

Figure 1B is a top plan view of this embodiment ;

Figure 1C is an elevation of this embodiment with the incremental measuring system in lifted position ;

Figure 2A is an elevation of a second embodiment of the invention likewise applied to a record player, wherein the speed of the turntable is measured optically ;

Figure 2B is an enlarged view of the optical sensors of Figure 2A ;

Figure 2C is a top plan view of the device of Figure 2A ;

Figure 2D is an enlarged view of the optical marking on the turntable of Figure 2C ;

Figure 3A is a top plan view of a third embodiment of the invention, likewise applied to a record player, wherein the speed of the turntable is measured by means of a Hall sensor ;

Figure 3B is an enlarged view of the Hall sensor of Figure 3A ;

Figure 4A is a fourth embodiment of the invention wherein the movable element is a belt driven by an electric motor via a slide coupling; and

Figure 4B is an elevation of the embodiment of Figure 4A.

Figures 1A-1C illustrate a first embodiment of the invention. This embodiment has the advantage of using a conventional record player 18 as the manually controllable movable element. This device can therefore be used by a disc jockey without excessive difficulty of adaptation.

By means of a transmission belt 12, a disc 16 drives an incremental measuring system 11 available on the technical market under the name of incremental decoder or angle encoder. When the disc rotates, pulses occurring after predetermined intervals of time are used directly as the sampling pulse for the recording and playback of the digital music recording. During recording, each pulse triggers a measurement of the analog music signal from an external source, e.g., from a CD player, and enters the result as a numerical value in a storage position of a dynamic computer memory (not shown). Here the individual measurements lie one directly behind the other in the memory. It is to be heeded that the measuring system is a high-definition one. If satisfactory quality of the music reproduction is to be achieved, the sampling rate should yield 40,000 measurements per second. At the normal rotation time of a record (speed of rotation 33.33 rpm) of 1.8 seconds, the measuring system must be capable of handling 72,000 pulses per rotation, or 18 angular seconds. During playback, the direction of rotation is evaluated in addition. Upon arrival of a pulse, the following and/or preceding storage

position is converted, depending on the the direction of rotation, from digital to analog.

The software addressing the computer memory can thereafter be as sophisticated as desired ; as a minimum, however, it must check the addressing of the computer memory present for overflows ; if, during recording or forward playback, the pointer reaches the end address of the memory provided, the pointer is to be set at the starting address of the memory provided, or at the end address in the case of backward play and reaching the starting address, respectively. It is thereby achieved that if the maximum available recording time is exceeded, the oldest recording is overwritten, which represents approximately the same mechanism as an endless tape loop in an analog echo apparatus.

According to current standard requirements for digital music reproduction, the signal should be digitalized with 16-bit width and be two-channel, i.e., stereo. The result is a memory requirement of 16x2x40,000 = 1,280,000 bits or 160,000 bytes per second. Since the sampling rate during playback can reach high frequencies of up to 1 MHz owing to scratching and rapid positioning of the disc, this circumstance is to be taken into account in dimensioning the computer control, software, and measuring system, otherwise the system loses the momentary playback positions and is not playable.

Since the turntable 15 of the record player is supposed to keep rotating at undiminished speed when the disc is moved, particular attention must be given to the record support : the balance between sliding and adhering to the record player should be ensured. In tests, a combination of PTFE-coated parchment 14 and very thin cellulose nonwoven 17 has proved best. The parchment should be cemented to the rubber mat 15 of the record player with a non-hardening adhesive spray in order to prevent wrinkling of the parchment over time.

Figures 2A-2D illustrate a second embodiment of the invention, likewise applied to a record player. The turntable 16 of the record player comprises a pattern—in this example a pattern of alternating black 20 and

white 23 marks. Two optical sensors 21 placed a short distance 22 above the turntable supply to a processing unit (not shown) a signal determined by the color of the mark just below each sensor. As a function of the signals supplied by the two optical sensors 21, the processing unit then determines the speed of rotation of the turntable of the record player. Two shifted optical sensors are necessary for determining the direction of rotation as well.

An analog audio signal coming from an external source, e.g., a CD player or a microphon, is then sampled at a frequency determined by the speed of rotation of the turntable.

A number of marks sufficient for obtaining the necessary resolution must be provided. To avoid the marks being too fine, interpolation of the signal coming from the sensors is preferable. Any type of optical sensor 21 may be provided, e.g., also a sensor using an optical fiber transporting a light beam collimated by a lens on the turntable. In a modification, it is also possible to use known marble sensors to determine the speed of the element 16.

This embodiment having an optical sensor, however, presents the drawback of being sensitive to dust and debris on the turntable.

Figures 3A and 3B illustrate another embodiment of the invention which is advantageous from this point of view. The speed of the turntable 16 of the record player is measured by means of a fixed magnetoinductive sensor 31 co-operating with a serrated ferromagnetic ring 30 on the turntable of the record player.

The invention is obviously not limited to this type of sensor, and any sensor or known device permitting the speed and direction of rotation of the turntable to be determined may also be used. Hall-effect sensors may thus be used advantageously. Likewise, it is possible to place upon the turntable 16 a magnetic film on which increments read by a stationary magnetic head are recorded.

All the preceding embodiments relate to devices adapted to conventional record players. However, the turntable 16 of the record player is used by the disc jockey only as a manipulatable element to control the speed of reproduction of an external audio source (not shown).

Figures 4A and 4B illustrate an embodiment of the invention in which no record player is used.

A controllable servomotor 40 drives a cylinder 42 via a slide coupling 41. A second cylinder 43 connected to the measuring system 44 is driven by the first cylinder 42 by means of a wide belt 45.

The disc jockey can manipulate and move the belt 45 by means of a handle 46 and thus act upon the speed and direction of rotation of the second cylinder 43. The measuring system 44 uses these parameters to determine the speed of reproduction of an audio signal coming from an external source.

It will be noted that—as in the preceding embodiments using a record player—this device permits normal sound reproduction when the disc jockey does not act upon the movable element 45, the second cylinder being driven in this case at a normal speed by the servomotor 40.

Other embodiments and modifications also making it possible to pass easily from a normal speed of movement of an element to a manipulated speed may readily be imagined and applied in devices making it possible to pass quickly from a normal playback speed of an audio signal to a manipulated speed.

The electronic part of the device comprises a sampling buffer.

In a first modification, the analog signal coming from a conventional analog source, for instance a microphon, is sampled at a constant frequency and stored in the sampling buffer. If the data are available in digital form, they can obviously also be stored directly in the buffer. For playback, the samples stored in the buffer are read successively at each reading pulse, the frequency

of the reading pulses depending on the speed of the movable element (16, 45). The samples read are then converted into analog signals by a digital-to-analog converter and reproduced.

In a second modification, the samples are stored in the sampling buffer at a speed inversely proportional to the speed of movement of the movable element (16 ; 45) and are read at a constant speed.

Claims

1. A digital processing device for an audio signal, comprising at least one element (16 ; 45) which moves during the reproduction of said audio signal, the speed and the direction of reproduction of said audio signal being manually controllable by control of the speed and direction of said element.

2. A digital processing device according to claim 1, wherein said element (16) is a rotating element.

3. A digital processing device according to claim 1, wherein said element (16 ; 45) is driven by an electric motor, the driving direction and speed being normally constant but capable of being manipulated manually by acting directly upon said element.

4. A digital processing device according to claim 3, further comprising at least one sensor (11 ; 21 ; 31 ; 44) permitting the speed and direction of movement of said element (16 ; 45) to be determined, the audio signal coming from an external source, and the speed and the direction of reproduction of said audio signal being a function of the data coming from said sensor or sensors.

5. A digital processing device according to claim 4, further comprising a visual pattern (20, 23) joined to said element (16 ; 45), said sensor or sensors (11 ; 21 ; 44) being stationary whereas said element (16 ; 45) is movable, said sensor or sensors being of the optical type.

6. A digital processing device according to claim 5, wherein said sensor is of the marble type.

7. A digital processing device according to claim 4, wherein said sensor or sensors (31) are of the magnetoinductive type.

8. A digital processing device according to claim 4, further comprising a magnetic film joined to said element (16 ; 45) and storing

increments, said sensor (11 ; 21 ; 44) being stationary whereas said element (16 ; 45) is movable, said sensor or sensors being of the magnetic type and being disposed so as to read said increments stored on said film.

9. A digital processing device according to one of the claims 4-8, wherein said element is made up of a record player turntable (16).

10.A digital processing device according to one of the claims 4-8, wherein said element (45) is driven by an electric motor via a slide coupling (41).

11.A digital processing device according to claim 1 or 2, further comprising :

a sampling buffer,

sampling pulse generating means capable of generating sampling pulses at a rate which is a function of the speed of movement of said element,

sample and store means for sampling and storing samples of said audio signal in said sampling buffer at each sampling pulse, and

reading means for reading samples out of said sampling buffer at a constant rate.

12.A digital processing device according to claim 1 or 2, further comprising :

a sampling buffer,

sampling pulse generating means capable of generating sampling pulses at a constant rate which is a function of the speed of movement of said element,

sample and store means for sampling and storing samples of said audio signal in said sampling buffer at each sampling pulse, and

reading means for reading samples out of said sampling buffer at a rate which is a function of the speed of movement of said element.

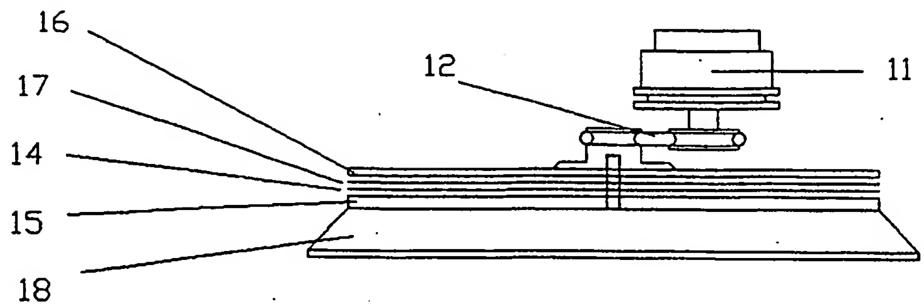

Fig. 1A

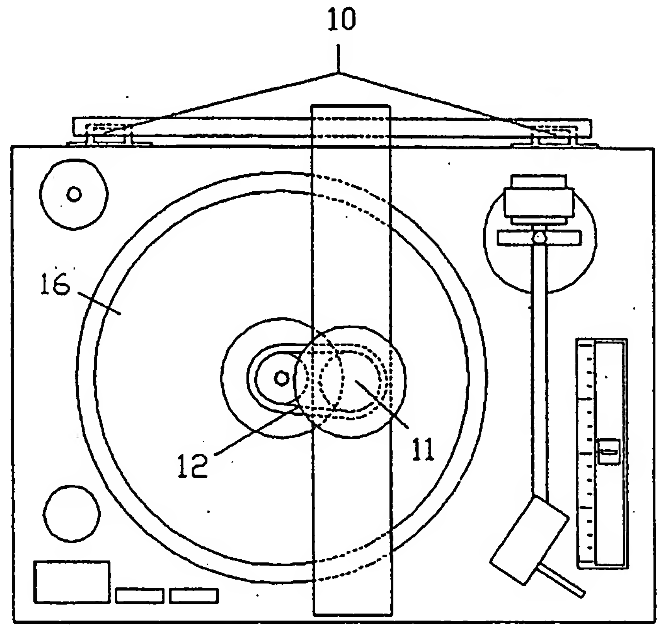

Fig. 1B

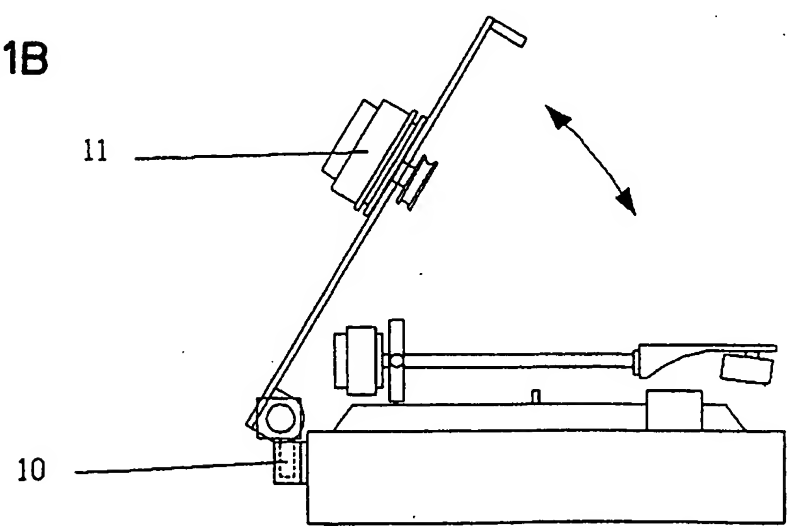

Fig. 1C

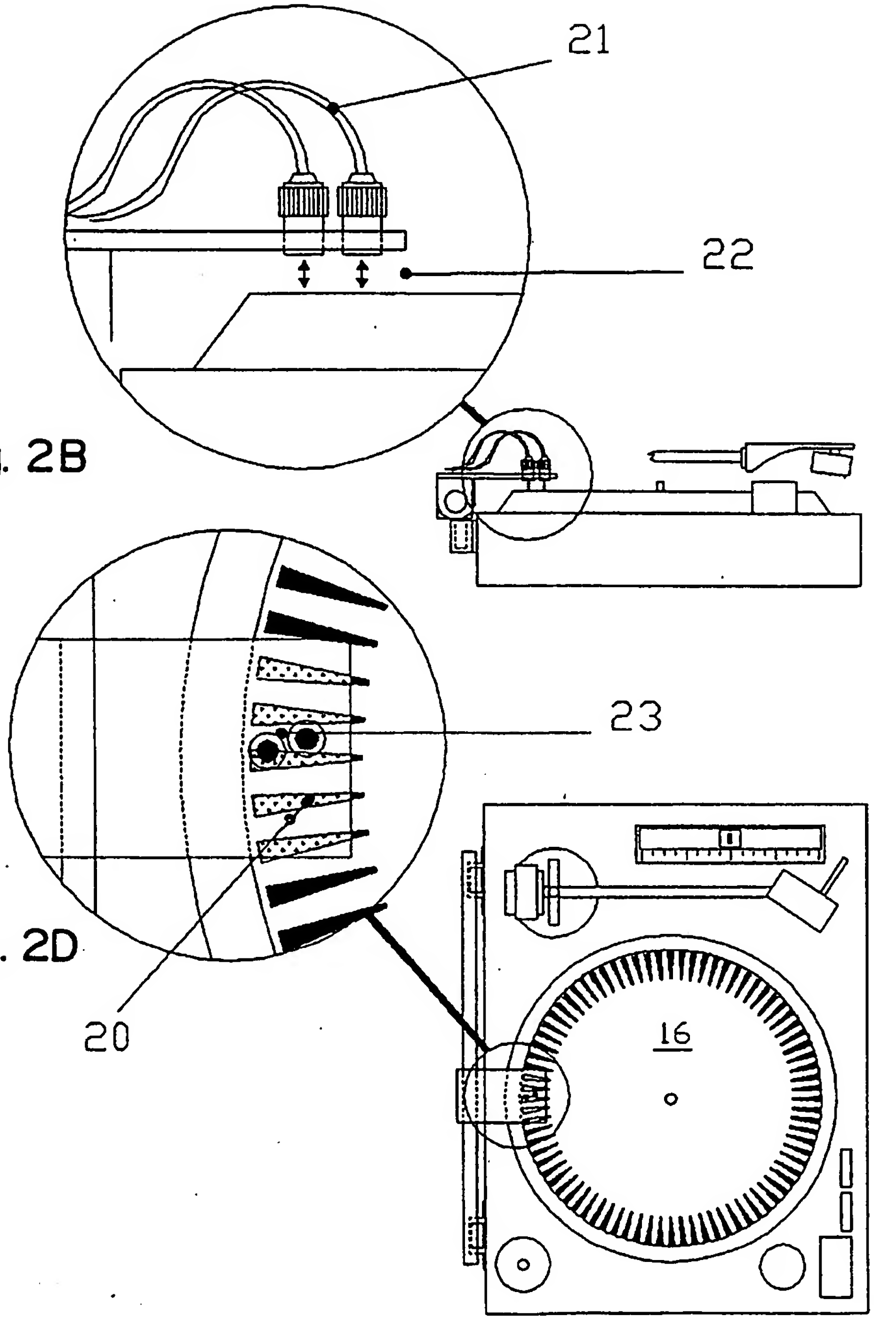

Fig. 2B

Fig. 2A

Fig. 2D

Fig. 2C

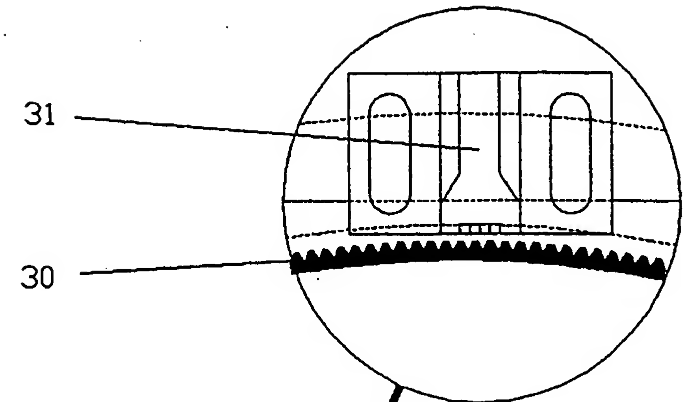

Fig. 3B

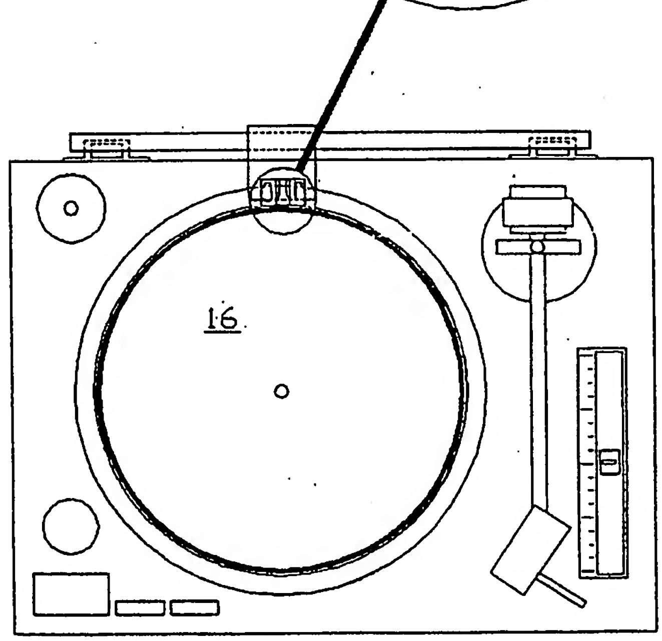

Fig. 3A

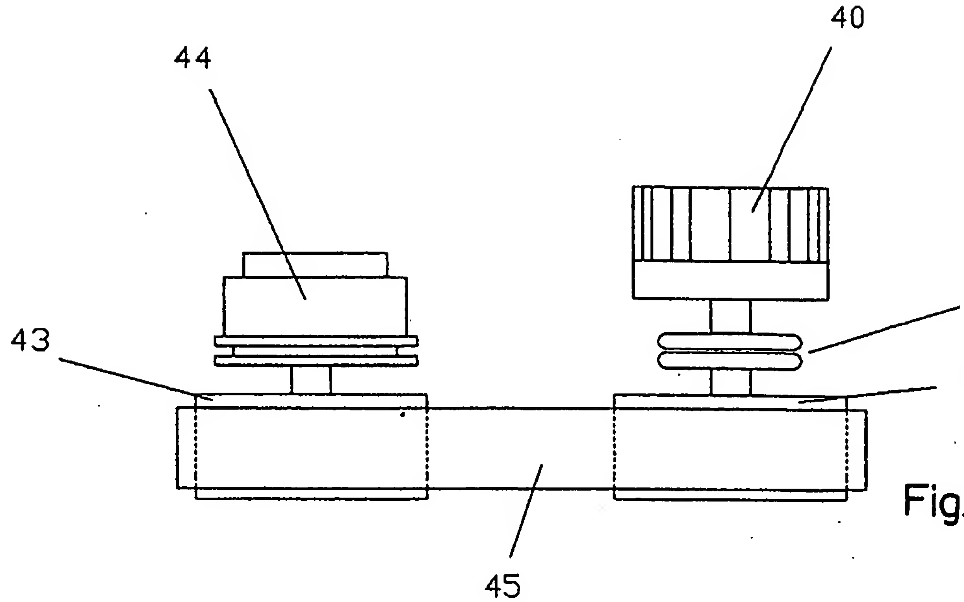

Fig. 4A

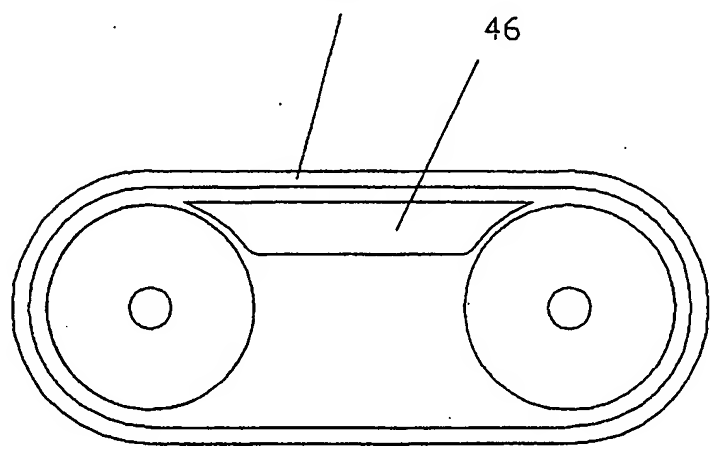

Fig. 4B

INTERNATIONAL SEARCH REPORT

Inten al Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G11B19/02 G11B20/10 G10H1/00

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Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G11B G10H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	PATENT ABSTRACTS OF JAPAN vol. 018, no. 353 (P-1764), 4 July 1994 & JP,A,06 089501 (CASIO COMPUT CO LTD), 29 March 1994, see abstract	1-4,11, 12 5-9
X	US,A,5 350 882 (KOGUCHI SATORU ET AL) 27 September 1994 see column 1, line 65 - column 3, line 8 see column 5, line 15 - column 6, line 65 see column 15, line 55 - column 17, line 3 see column 19, line 49 - column 19, line 68 see figures 1,9-16,18	1-5,7-12

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[X] Further documents are listed in the continuation of box C.

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Date of the actual completion of the international search	Date of mailing of the international search report
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X	PATENT ABSTRACTS OF JAPAN vol. 017, no. 658 (P-1654), 6 December 1993 & JP,A,05 216476 (YAMAHA CORP), 27 August 1993,	1
A	see abstract	11,12
A	EP,A,0 577 104 (ROCKWELL INTERNATIONAL CORP) 5 January 1994 see the whole document	5
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INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte[illegible]al Application No
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